

New Course Proposal

Igo Math

Natural and Artificial Intelligence and the Game of Go

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“Success at go requires the tactic of the soldier, the exactness of the mathematician, the imagination of the artist, the inspiration of the poet, the calm of the philosopher, and the greatest intelligence.”

Zhang Yunqi, Discovering weiqi, internal document of the Chinese Weiqi Institute 1991, Beijing



Image:REUTERS/STRINGER

1 Course Description and Syllabus

The proposed ‘Igo Math’ course aims to introduce the mathematics of the artificial intelligence algorithms that underlie the rapid changes we see in our technological society. Instead of taking a technical only path, the course chooses a playful way. It will discuss the techniques of automated thinking by analyzing Go, the ancient board game. To some extent, the chosen topic acts a ‘decoy’, while the real purpose of the course is the **increased awareness of someone’s own cognitive skills and improved communication ability for sharing thought processes**. For a detailed description, please see the developed syllabus attached.

2 Rationale

The motivation for this course stems from three different sources:

- automated thinking has to be understood, both its technical details and its impact,
- mathematics has to break out from the traditional lecturing style,

- knowledge gained from different areas of study have to be synthesized and integrated.

Automation repeatedly brings in the spectre of mass unemployment and civil unrest. Historically, the waves of mechanizations always turned out to be a good result: increased productivity and more meaningful jobs. It is now hotly debated whether the advance of AI is an entirely different situation or not. Without taking sides, we argue that automated thinking has to be studied and taught.

Artificial intelligence is engineering discipline rooted in mathematics. There are numerous applications, therefore discussing all of them would require several courses. The game of Go is an accessible and psychologically very important application of artificial intelligence, therefore it is possible and worth studying within the Liberal Arts curriculum.

Bad perception of mathematics. Unfortunately, for most people mathematics is perceived as a problem itself and not a cognitive tool that is designed for making complex things easier to handle. In traditional courses, its usefulness might be justified only by the requirements of more advanced maths courses.

Here we try to short-circuit the mathematical theory and real world application loop by concentrating on one particular game. Students will meet the questions first in their games. By facing the challenges and sensing their difficulties, they will be more receptive for the mathematical tools introduced afterwards. Hopefully, this will help the students to see the real nature of mathematics, a tool that makes complex problems easier.

Curriculum integration. Cognitive studies of learning identified *the lack of transfer* as a factor inducing poor performance in education. Knowledge obtained in a topic, even if the connection is obvious, does not move automatically to other topics or fields. Thus, there is a need for courses where logical and metaphorical connections are explicitly discussed. This course is meant to provide coherence for mathematics and computing courses. Beyond that, it aims to discuss the connections with history and art, business and politics. See Section 5 for more details.

2.1 Previous developments leading to this course

In 2010, in Hungary, I had a Go session within a talent nurturing program for high school students. The aim of the session was to introduce the classical heuristic method of mathematical problem solving (György Pólya: *How To Solve It*, 1945) in a more accessible scenario, in solving Go problems. The session report and the insights gained was written up in a subsequent publication.

”How to solve it?” - The tsumego session

Annales Mathematicae et Informaticae, Vol 38 2011, pp 137-145

http://ami.ektf.hu/uploads/papers/finalpdf/AMI_38_from137to145.pdf

3 Intended Audience

The intended audience is a broad spectrum of students ranging from those choosing a career path involving information technologies, through students interested in mathematics and computing in general, to those who would simply enjoy an entertaining and challenging intellectual adventure. The direct benefits – acquiring computational thinking and agility in problem solving – have an almost universal applicability.

4 Special Features

The course is non-traditional, since it will explicitly contain play and solving puzzles as a classroom activity. In solving problems, special emphasis will be made on the existence of several solutions, and their stylistic differences. Student interactions (e.g. explaining solutions, concepts to each other) will be highly encouraged and rewarded when appropriate. It is expected that some students will be strong players, who learned the game before the course. However, this is not a problem, since there exists a

handicap system, making meaningful matches possible between players of unequal strength. Also, the mathematics of the game is still new material for Go players.

5 Relationship to Existing Curriculum

The proposed course has strong connections with existing courses. It uses material from other courses and also reinforces those concepts by putting them into the particular context of understanding a game. Following AIU's unrestricted curriculum model, these are not requirements. However, students can benefit from synthesizing knowledge gained from these other courses and the insights from Igo Math. In detail, the interactions are the following.

- MAT150 College Algebra, MAT100 Mathematics for Liberal Arts introduces formal logic and mathematical rigour in general, Igo Math will do the same in a particular case. There is also a deep connection between mathematical problem solving (choosing the next operation) and finding the best move in a local fight.
- MAT200 Statistics deals with uncertain knowledge. This is also a requirement for computationally hard problems where combinatorial complexity denies complete knowledge. Also, ranking the players is based on assessing the probability of winning against other players.
- CCS125 Programming Principles, MAT245 Poetry of Programming support the algorithmic thinking and provide a direct, hands on experience of the capabilities of computers.
- MAT240 Mathematics Behind the Technological Society explains mathematically how computers work, which is helpful in understanding how thinking can be mechanized.
- CCS220 Machine learning and big data discusses a wide range of applications of data science. The proposed course studies one application in depth, reinforcing the understanding of those concepts.

Further possible connections that may enrich the proposed course by interacting with other courses (that I'm not fully aware of at the moment).

- Art: the simple aesthetics of the Go equipment, its avoidance of symmetry; games considered as performances, work of art.
- Business: businesspeople from Asia often use Go as a training tool for preparing strategic decisions in for their companies. 'Live and let live' way of thinking.
- History: the development of the game follows and mirrors the history of the three Go "kingdoms", China, Korea and Japan.
- Philosophy: emergence – how simple rules lead to complex behaviour; the parallel between the Buddhist path towards enlightenment and learning Go.
- Personal development: according to a legend, Go was invented by a king to educate his heir. Indeed Go develops the sense of balance and decision making skills. The rating systems is modelled after the ones used in martial arts.
- Biology: artificial neural networks made breakthrough progress possible for Go engines, knowing the biological description of neural cells could deepen the understanding of machine learning techniques.

6 Evaluation Plan

The success and ongoing need for the course will be determined by students demand, by student feedback and by student achievements. The ultimate success of course has a simple criterion: whether or not Go playing at AIU would persist outside the classroom.

7 Criticisms

Here comment on the feedback received from faculty members, students and other scholars in the field. We think through the objections that were and may be raised against the course.

Board games are doomed.

With the existence of oracle level AI playing these games, why would people bother?

There are machines that can move faster than humans, still people enjoy running. Exercise is also healthy for their bodies. Similarly, the existence of a mechanized stronger player does not invalidate the beneficial effects of playing Go on the human mind.

Also, noted in the classic work (Go and go-moku – the oriental board games, Edward Lasker, 1960: “I believe we remain interested in a game only as long as it mystifies us. As soon as we know all about it play becomes mechanical and boring.” The raise of strong AI Go players does not imply full understanding of the game. Weights in a neural network are not easy to interpret. It is ‘only’ a new master to learn from.

Playing is not a scholarly activity.

How does playing, as in entertainment, contribute to studies?

It’s not a passive entertainment (like binge watching TV-series). Playing Go is considered to be equivalent to an advanced Mathematics course.

There will be no interest in the course.

Are people still interested in the game?

Informal survey showed there are no Go players among the students. It is difficult to tell whether this is a good sign or not for predicting future interest. On the other hand, AI is very much in the everyday discourse, and the course does offer a deep understanding of how the currently available AIs work. In any case, once approved, the course will be advertised (posters with the attractive visuals of the game) beyond the official course announcements, in order to avoid the ‘I’ve never heard of it’ phenomenon.

Would students be scared off by the advanced mathematics?

The mathematics content of the course is advanced only in the sense that it is not taught in schools, and not by its inherent difficulty. However, it may still be perceived as a difficult subject. Therefore, emphasis is shifted away from the traditional exam style. The two exams contribute to final grade only by 20% each. Hopefully this will ease the anxiety associated with math exams. However, with the homework assignments, the mathematics part still adds up to 60%, so the changes do not compromise the integrity of the course.

Missing expertise.

Is professional Go knowledge required for teaching?

Yes, it is. However, the course is not about teaching advanced playing skills. It is about learning metacognition skills and understanding AIs.